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USE OF GARLIC AS A NATURAL FEED ADDITIVE IN LAYING HEN DIETS UNDER THE DESERT CONDITIONS

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This experiment was carried out at Ras Sudr research station, Southern Sinai during summer period (1st May till 21 August) to evaluate garlic as a natural feed additive in laying hen diets, and its effects on body weight change, egg production, feed utilization, digestibility coefficients, egg quality and some physiological traits in egg yolk and blood. A total number of 60 Hy-Line Brown commercial egg-type hens of 20 weeks of age were randomly distributed into 5 experimental groups of 12 hens each. Each group involved 3 replicates, 4 hens each. Garlic was added to diets at levels 0, 0.5, 1, 1.5 and 2 kg /100 kg diet, respectively. The total period of the experiment was 16 weeks which divided into four stages of four weeks each. The traits were calculated at intervals and for the entire experimental period.

Garlic levels had no significant effect on the final body weight and weight gain (g), although 1.5% garlic group showed the highest values of 1803 and 268 g for the final body weight and weight gain compared to the other treatments. Egg production percentage was significantly ($P<0.05$ & 0.01) increased due to the increase of garlic level not only at the interval periods but also throughout the total experiment. There were no significant effects on egg weight due to garlic supplementation in laying hen diets. Total egg mass (kg/hen) recorded the highest value of 5.008 kg in 1.5% garlic group, while the lowest ones (4.443 kg/hen) was encountered in the control group.

Hens fed on diets supplemented with garlic (particularly at higher levels) consumed significantly ($P<0.05$) more feed at all experimental intervals. Garlic levels showed no significant effects on feed conversion rate (kg feed/kg eggs). A significant increase ($P < 0.05$) in Ether Extract, EE digestibility was noticed with the increasing of garlic level in diet, while the other digestibility coefficients were not influenced by garlic levels in diet. There were no significant effects on egg quality measurements due to using garlic up to 2% in layer diets. The best economical efficiency was noticed in 1.5% garlic group followed by those fed on 1% garlic. The inclusion of garlic in diets was followed by a decrease in cholesterol and total lipids in each of blood and egg yolk.

In conclusion: Fresh garlic could be recommended at a level of 1.5 kg/100 kg diet of laying hens during summer period under the desert conditions. This could improve the egg production performance, feed efficiency utilization, reduces the cholesterol and total lipids in blood and egg yolk and may reduce the side effects of high temperature or any stress conditions.

Keywords: garlic, desert conditions, body weight changes, egg production, feed utilization, digestibility coefficients, blood measurements, economical efficiency, laying hens.

Recently, several studies revealed the importance of medical plants as natural feed additives in poultry diets to improve the quantity and quality of their products. At the same time reducing the deleterious effects of the chemical additives in poultry products (El- Nawawy, 1991; El- Deeb, 1994; Abdo, 1998 and Mohamed *et al.* 2000). Garlic *(Allium sativum)* is one of alliaceous plants that grows widely in Egypt and consumed as human feed and used also in the medical purposes. Garlic is considered as antiarherosceleratic agent, as it has hypo-lipemic and hypo-cholesterolemic properties (Chi *et al.*, 1982).

It is well known that the consumer tends to consume food with lower cholesterol content to avoid the serious diseases such as coronary. In this respect some of research studies cleared the importance of garlic in reducing of cholesterol and total lipids in blood and carcass meat (El-Nawawy, 1991; Konjufca *et al.*, 1997 and Abdo, 1998).

It must be stated that an egg weighing 60 g contains between 240 and 280 mg of cholesterol located entirely in the yolk (Larbier and Leclercq, 1994). However, cholesterol content in egg yolk varied greatly according to egg size, egg production, breed and feeding regime (Mc Naughton, 1978 and Scholtyssek, 1987).

Egyptian garlic was inserted in laying hen diets under the normal conditions and showed a positive result in reducing egg cholesterol and total lipids in blood. It also improved body weight, feed consumption and feed conversion values (El-Deeb, 1994; Mohamed *et al.*, 2000 and El-Kaiaty *et al.*, 2002).

The natural feed additives may be given to birds to improve their physiological and productive performance under stress conditions. In this respect, Afifi (2001) reported that body weight, weight gain, feed consumption or feed conversion of broiler chickens fed on 2 to 3% Nigella sativa seeds at hot climate conditions were significantly ($P<0.05$) improved. In the same way Tollba and Hassan (2003) found that adding black Cumin or garlic as natural feed additives in broiler diet under high temperature (38^{0}C for 3 hrs from 35 to 40 days of age) increased live body weight, weight gain, feed conversion and reduced cholesterol and total lipids than that under the normal conditions.

There is no literature available on the utilization of fresh garlic in laying hens during summer months under the desert conditions. Therefore, the present work was designed to shed some light on the effect of fresh garlic under the desert conditions on body weight changes, egg production performance, feed utilization, digestibility coefficients, egg quality and some of physiological parameters in egg yolk and blood in laying hens.

MATERIALS AND METHODS

This experiment was carried out at Ras Sudr research station, during summer period under the desert conditions in order to evaluate fresh garlic as a natural feed additive in laying hen diets. The aim of the experiment was to study the effect of garlic on body weight change, egg production performance, feed utilization, digestibility coefficients, egg quality measurements and some of physiological parameters in egg yolk and blood.

Birds and Management

A total number of 60 Hy-Line Brown commercial egg-type of 20 weeks of age were randomly distributed into 5 experimental groups of 12 hens each. Each group involved 3 replicates, 4 hens each. Hens were housed in separate layer cages in open-system house. They were offered a layer diet of 17% protein and 2775 Kcal ME/kg (Table 1). Water and feed were provided *ad. lib.* and hens were exposed to 16 hours light and 8 hours dark as daily program throughout the experimental period. The experiment lasted 16 weeks. The total period of the experiment was divided into four stages of four weeks each. The traits were calculated at intervals and for the entire experimental period. The outer husks of garlic bulbs were pooled off, cloves were minced, and ground then stored fresh in a deep freezer. Fresh garlic were mixed to the diet at levels 0, 0.5, 1.0, 1.5 and 2 kg/ 100 kg diet.

Collecting Data

Hens were weighed at the beginning and end of the experiment and body weight gain was calculated for each hen and treatment group by subtracting individual body weight of hens at 36 weeks from that of 20 weeks of age.

Egg weights in grams were recorded daily for each hen throughout the experimental period. Average egg weight, egg production percentage and egg mass were calculated for each experimental period. Feed consumption in grams per hen was recorded weekly and average feed consumption was calculated for each treatment. Feed conversion rate (as kg feed/kg eggs) was calculated as kg feed consumed per kg egg produced.

TABLE (1). Composition and calculated analysis of the experimental diet*

Ingredients	%
Yellow corn	65.1
Soybean meal, 44%	13.1
Wheat bran	4
Layer concentrate[1]	10
NaCl	0.50
Vit. & Min. premix[2]	0.30
Lime stone	7.00
Total	100
Calculated analysis	
ME, Kcal/Kg	2775
CP	17.00
CF	3.09
Ca	3.54
Av. P	0.55
Lysine	0.87
TSAA	0.63

* Calculated according to N.R.C. (1994)

[1] Layer concentrate contains: 51% CP, 2500 Kcal ME/Kg, 8.0% Ca, 4% av. P., 1.5% Meth., 2% Meth. & Cystine and 2.9% Lysine.

[2] Vit. & Min. premix per Kg. of the diet contain: Vit. A 12.000 IU, Vit. D3 2000 IU, Vit. E 10 mg, Vit. K 2 mg, Vit. B1 1 mg, Vit. B2 4 mg, Vit. B6 1.5 mg, Vit. B12 10 mcg, Pantothenic 10 mg, Niacin 20 mg, Folic acid 1 mg, Biotin 50 mcg, Choline 500 mg, Iron 30 mg, Manganese 40 mg, Copper 3 mg, Iodine 0.3 mg, Cobalt 0.2 mg, Zinc 45 mg and Selenium 0.1 mg.

A sample of 12 eggs from each group was used to determine the egg quality. In this respect, eggs were individually weighed and broken out to measure egg quality. Yolk, albumen and shell weight were calculated as a percentage of the egg weight. Egg shell thickness was measured in μm by using a micrometer. Egg shape index was calculated according to Romanoff and Romanoff (1949) as an egg diameter divided by egg length. Yolk index calculated according to Funk *et al.* (1958), as yolk height divided by yolk diameter. Haugh unit was calculated according to Eisen *et al.* (1962) using the calculation chart for rapid conversion of egg weight and albumen height.

After measuring the egg quality, 3 yolk samples from each treatment were separated from the broken eggs, calculated and extracted to determine cholesterol and total lipids according to Folch *et al.* (1957).

Chemical analysis (Moisture, CP, EE and Ash%) of 30 eggs (6 eggs from each treatment) were carried out according to A.O.A.C. (1990).

Digestibility trial was carried out to determine the digestion coefficients of the nutrients (OM, CP, EE, CF and NFE%). Three hens of each group was chosen with a total number of 15 layers from the total groups. Faecal nitrogen was determined following the procedure outlined by Jacobsen *et al.* (1960). Urinary organic matter was calculated according to Abou-Raya and Galal (1971). Chemical analysis of diets and excreta were conducted according to A.O.A.C (1990).

At the end of the experiment, 3 hens from each treatment were slaughtered. A number of 3 blood samples were obtained from Three hens per treatment, with total number of 15 samples for all groups. Blood samples were centrifuged at 4000 ppm for 15 minutes. Clear serum was separated, then stored in a deep freezer at – 20°C until the time of biological analysis. Total lipids was determined according to the method of Zollner and Kirsch (1962). Cholesterol was determined according to Stein (1986). Glucose, Ca and inorganic P were measured according to guidelines and recommendation by specific diagnostic kits (Bio Merieux, France) according to guidelines and recommendation of Bogin and Keller (1987). Globulin was calculated by the difference between total protein and albumin, since the fibrinogen usually comprises a negligible fraction (Sturkie, 1976).

Data were statistically analyzed using the General Linear Model Procedure (SAS Institute, 1994). Duncan's multiple range test was used to test the significance of mean differences (Duncan, 1955).

RESULTS AND DISCUSSION

Effects of Garlic on Body Weight Change and Egg Production Performance

The effects of garlic levels on body weight changes and egg production performance are shown in table (2). Garlic levels had no significant effect on the final body weight and weight gain. Garlic group of 1.5% showed the highest values of 1803 and 268 g for the final body weight and weight gain respectively compared to the other experimental treatments. This result was in harmony with the findings of Prasad and Pandey (1995), Mohamed *et al.* (2000) and El-Kaiaty *et al.* (2002). However, Mohamed *et al.* (2000) revealed that both garlic and onion stimulate the growth rate as natural growth promoters which, in turns, increases the body weight of hens. However, broiler chicks showed the highest significant values in body weight and weight gain when they received a diet supplemented with 1% garlic under high environmental conditions (Tollba and Hassan, 2003).

TABLE (2). Effect of garlic levels on body weight gain and egg production performance (Means ± SE)

Parameters	Garlic %					Sig.
	0	0.5	1	1.5	2	
Initial body wt (g)	1529.5 ± 43.00	1508.6±42.8	1533.3±41.1	1535.0±49.5	1511.3±47.8	N.S.
Final body wt (g)	1770.2± 54.00	1723.9±47.0	1710.0±50.1	1803.3±42.7	1740.0±39.9	N.S.
Body wt gain (g)	240.7± 33.1	215.3±37.0	176.7±27.3	268.0±29.0	228.7±35.9	N.S.
Egg production %						
20-24 wks	$46.40^{c} \pm 2.51$	$50.23^{bc} \pm 2.13$	$51.41^{bc} \pm 2.38$	$59.25^{a} \pm 3.1$	$55.57^{ab} \pm 3.55$	**
24-28 wks	$74.56^{b} \pm 2.50$	$77.43^{ab} \pm 2.06$	$80.49^{ab} \pm 3.90$	$85.30^{a} \pm 2.8$	$83.63^{a} \pm 2.70$	*
28-32 wks	$79.2^{b} \pm 2.47$	$83.71^{ab} \pm 2.33$	$84.30^{ab} \pm 2.08$	$88.19^{a} \pm 2.4$	$84.00^{ab} \pm 2.14$	*
32-36 wks	$81.00^{b} \pm 2.87$	$82.90^{ab} \pm 1.93$	$85.29^{ab} \pm 2.59$	$89.9^{a} \pm 2.06$	$86.30^{ab} \pm 2.32$	*
Overall means	$70.29^{b} \pm 2.60$	$73.56^{ab} \pm 1.93$	$75.37^{ab} \pm 2.77$	$80.66^{a} \pm 3.07$	$77.37^{ab} \pm 2.90$	**
Egg wt. (g)						
20-24 wks	49.08±1.28	49.20±1.50	50.82±1.10	50.29±1.68	48.79±2.01	N.S.
24-28 wks	55.62±1.39	56.74±1.33	56.08±1.32	56.09±1.38	55.46±1.40	N.S.
28-32 wks	58.65±1.58	58.40±1.70	58.50±1.26	58.09±1.60	57.93±1.42	N.S.
32-36 wks	59.28±1.31	59.01±1.26	58.58±1.41	58.84±1.27	58.34±1.37	N.S.
Overall means	55.65±1.23	55.84±1.10	55.99±1.35	55.82±1.38	55.12±1.51	N.S.
Egg mass (Kg)						
20-24 wks	$0.638^{b} \pm 0.04$	$0.691^{b} \pm 0.06$	$0.731^{ab} \pm 0.06$	$0.834^{a} \pm 0.08$	$0.762^{ab} \pm 0.07$	*
24-28 wks	$1.161^{b} \pm 0.09$	$1.230^{ab} \pm 0.10$	$1.264^{ab} \pm 0.11$	$1.339^{a} \pm 0.13$	$1.298^{a} \pm 0.11$	*
28-32 wks	1.3000±0.10	1.368±0.08	1.381±0.09	1.434±0.10	1.363±0.10	N.S.
32-36 wks	1.344±0.09	1.369±0.10	1.399±0.12	1.481±0.11	1.337±0.09	N.S.
(1-16 weeks)	$4.443^{c} \pm 0.12$	$4.658^{b} \pm 0.13$	$4.775^{b} \pm 0.12$	$5.088^{a} \pm 0.11$	$4.760^{b} \pm 0.11$	**

a,b,c means within a row with different superscripts are significantly different (P< 0.05)

Sig = Significance N.S. = non significant * = (P< 0.05) ** = (P< 0.01)

TSAA=total sulphur amino acid

Egg production percentage was significantly (P<0.05 & 0.01) increased due to the increase of garlic level not only at the interval periods but also throughout the total experiment (Table 2). However, 1.5% garlic in laying hen diets showed the highest egg production percentage compared to the other treatments. Values in this concern were 70.29, 73.56, 75.37, 80.66 and 77.37% for 0, 0.5, 1.0, 1.5 and 2.0% garlic groups, respectively. This mean that 1.5% garlic group produced eggs with 10% more than those of the control group. It is worth to note that garlic levels in diets appeared usually positive improvement in egg production percentage and surpassed those of the control group.

There were no significant effects on egg weight due to garlic supplementation in diets (Table 2). The overall mean of egg weight were 55.65, 55.84, 55.99, 55.82 and 55.12 g for garlic levels of 0, 0.5, 1.0, 1.5 and 2%, in diets, respectively.

Total egg mass (kg/hen) followed nearly the same trend of egg production percentage, where garlic supplementation up to 1.5% in diet followed by a positive improvement for this trait. The effect of garlic levels on egg mass throughout the total experimental period was highly significant (P<0.01). In this connection egg mass values were 4.443, 4.658, 4.775, 5.088

and 4.760 kg for 0, 0.5, 1.0, 1.5 and 2.0% garlic groups, respectively. These results explained that the garlic up to 1.5% in laying hen diet could enhance egg production percentage and egg mass.

The improvement in egg production performance in the present study was previously confirmed by Sharma *et al.* (1979) who reported an improvement in egg production with 4% at a level of 1% garlic and a non significant decrease in another group fed 2% garlic in diet. In the same way, Mohamed *et al.* (2000) observed a positive effect of 5.8% and 7.2% in egg production of IZA Brown and Fayoumi hens, respectively. On the other hand, El-Habbak *et al.* (1989) obtained depression in egg production and an increase in egg weight of laying Japanese quail when they used garlic at levels of 2 and 4%. Also El-Kaiaty *et al.* (2002) stated no marked change in egg production rate at a level of 2% garlic in layer diets. However, the contradictions among these results may be due to the differences in strain, concentration of garlic, the nature of diets used or the age and physiological state of the bird (Reddy *et al.* 1991).

The decrease in egg production percentage and egg mass encountered in the present study at 2% garlic compared to that fed on 1.5% garlic (Table 2) may be attributed to that garlic at high level may contain unknown depressant factor (s) which could be directly involved in reducing egg production (El-Habbak *et al.*, 1989). However the same author recorded negative results in egg production performance at 4% garlic in quail diet.

Effects of Garlic on Feed Consumption and Feed Conversion

Feed utilization as affected by garlic levels are presented in table (3). It is noticed that hens fed on diets supplemented with garlic (particularly at higher levels) consumed more feed at all experimental intervals. However, average feed consumption were 106.79, 106.44, 108.09, 111.33 and 109.63 g/hen/day for 0, 0.5, 1.0, 1.5 and 2% garlic groups, respectively.

TABLE (3). Effect of garlic levels on feed consumption and feed conversion values (Means ± SE)

Parameters	Garlic %					Sig.
	0	0.5	1	1.5	2	
Feed consumption[1]						
20-24 wks	$94.82^{ab}\pm1.70$	$93.00^{b}\pm1.65$	$95.01^{ab}\pm1.93$	$98.90^{a}\pm1.79$	$97.02^{ab}\pm2.01$	*
24-28 wks	$108.13^{b}\pm2.00$	$110.17^{ab}\pm2.13$	$111.10^{ab}\pm1.99$	$113.9^{a}\pm2.53$	$110.80^{ab}\pm2.50$	*
28-32 wks	$111.03^{ab}\pm2.33$	$109.70^{b}\pm2.10$	$112.07^{ab}\pm2.00$	$115.03^{a}\pm2.50$	$113.9^{ab}\pm2.44$	*
32-36 wks	$113.2^{ab}\pm2.47$	$112.9^{b}\pm2.30$	$114.2^{ab}\pm2.20$	$117.5^{a}\pm2.60$	$116.8^{ab}\pm2.50$	*
Overall mean	$106.79^{b}\pm1.81$	$106.44^{b}\pm1.73$	$108.09^{ab}\pm1.97$	$111.33^{a}\pm1.60$	$109.63^{ab}\pm1.88$	*
Feed conversion[2]						
20-24 wks	$4.16^{a}\pm0.13$	$3.77^{ab}\pm0.12$	$3.64^{b}\pm0.13$	$3.32^{b}\pm0.11$	$3.56^{b}\pm0.10$	*
24-28 wks	2.61±0.09	2.50±0.08	2.46±0.08	2.38±0.10	2.39±0.07	N.S.
28-32 wks	2.39±0.06	2.25±0.09	2.27±0.07	2.24±0.06	2.33±0.08	N.S.
32-36 wks	2.36±0.05	2.30±0.10	2.28±0.10	2.22±0.12	2.45±0.10	N.S.
Overall mean	2.88±0.08	2.70±0.11	2.66±0.10	2.54±0.13	2.68±0.10	N.S.

1) g/hen/day 2) kg feed/ kg eggs

a,b,c means within a row with different superscripts are significantly different (P< 0.05)

Sig = Significance N.S. = non significant * = (P< 0.05)

Garlic levels showed no significant effects on feed conversion rate (kg feed/kg eggs) except at 24 weeks of age, where 1.5% garlic group showed the best significant ($P<0.05$) rate of 3.32 compared to the other experimental groups. However, at the other interval periods, 1.5% garlic in diet showed always insignificant improvement in feed conversion rate. The overall mean of feed conversion rate were 2.88, 2.70, 2.66, 2.54 and 2.68 for garlic groups, 0, 0.5, 1.0, 1.5 and 2%, respectively.

The higher feed consumption that was encountered when diet was supplemented with garlic was strongly confirmed by Sharma *et al.* (1979), Mohamed *et al.* (2000) and also reported by Tollba and Hassan (2003) in broiler chicks under high temperature conditions. This may be due to the palatability of diet supplemented with garlic depending mainly on the strong smelling odour of it. However, a higher level of garlic as 4% (El-Habbak *et al.*, 1989) or 2% (El-Kaiaty *et al.*, 2002) caused a decrease in feed consumption values. Moreover, garlic group of 1.5% consumed more feed than those of 2% group. Furthermore, Abdo (1998) reported that feed utilization of broilers were better at 3% garlic and not at 6% garlic in diet. However, the bird may benefit from the favorable components of garlic up to a certain limit to be varied according to species or the type of feeding.

Generally, the improvement in body weight gain, egg production performance and feed utilization of hens fed on garlic could explain the importance of garlic as a natural feed additive in laying hen diets. Some of components in garlic could be responsible for this improvement. For example, oleic, linoleic and linolenic acids are the major unsaturated fatty acids in garlic (Stoianova-Ianova and Tsutsuloval, 1974). At the same time, the unsaturated fatty acids plays an important role in growth than those of the saturated ones. Moreover, garlic bulbs contain an odorless; sulfur-containing amino acid derivative known as alliin. This alliin comes into contact with the enzyme allinase which converts it to allicin (Tyler, 1993). Allicin is the major antimicrobial factor as it showed a delayed and partial inhibition of protein synthesis of salmonella and other microbes. Therefore, garlic has traditionally been implicated as an antibacterial, antiviral, antifungal and antiparasitic (Abdo, 1998). Garlic has also a reasonable amounts of the minerals either macro or micro related to growth and essential for getting the optimal performance (Abou El-Wafa *et al.*, 2002).

The Effects of Garlic Levels on the Digestibility Coefficients of Nutrients

Digestibility coefficient values of nutrients as affected by garlic levels for the experimental diets are reported in table (4). It is worth to note a significant increase ($P < 0.05$) in EE digestibility with the increasing of garlic level in diet. Values in this respect were 79.3, 80.9, 82.08, 83.8 and 84.5 for 0, 0.5, 1.0, 1.5 and 2.0% garlic groups, respectively. Digestion coefficients of the other nutrients revealed insignificant effects due to garlic levels in diets. These results confirm the previous findings of Abdo (1998) on broilers and El-Kaiaty *et al.* (2002) on laying hens who reported a positive improvement in EE digestibility with the increasing of garlic in diet. A probable interpretation for the significant increase of EE digestibility with the increasing of garlic level in diet, is that garlic may enhance the fat digestion enzymes.

TABLE (4). Effect of garlic levels on digestibility coefficients of nutrients of the experimental diets (Means ± SE)

Traits	Garlic levels%					Sig.
	0	0.5	1	1.5	2	
OM%	75.81±0.55	76.00±0.60	75.93±0.63	76.30±0.59	75.77±0.71	N.S.
CP%	89.23±1.00	90.09±0.83	89.73±0.75	90.29±0.83	89.00±0.80	N.S.
EE%	79.30^{c}±0.71	80.90^{bc}±0.63	82.08^{ab}±0.60	83.80^{a}±0.73	84.50^{a}±0.81	*
CF%	21.5±0.73	20.80±0.70	21.00±0.63	20.92±0.70	21.30±0.65	N.S.
NFE%	76.26±0.70	77.05±0.61	75.93±0.58	76.81±0.75	76.00±0.72	N.S.

^{a,b}Means with different superscripts in the same raw are significantly different (P< 0.05).
N.S. = non significant

The Effects of Garlic Levels on Egg Quality Measurements

Egg quality measurements as affected by garlic levels in diets are described in table (5). There were no significant effects on all parameters due to using garlic up to 2% in layer diets. However, hens fed on 1.5% garlic showed insignificant higher egg weight followed by those fed on 2% garlic. Albumen, yolk and shell weight% showed no pronounced differentiation in their values among the experimental treatments. Haugh unit recorded the highest insignificant value of 79.93 in 1.5% garlic group compared to 74.90 in the control group. The highest value of shell thickness (338 µm) was encountered in 2% garlic group compared to 323 µm in the control ones.

TABLE (5). Effect of garlic levels on egg quality measurements (Means ± SE)

Traits	Garlic levels					Sig.
	Control	0.5%	1%	1.5%	2%	
Egg weight, g	57.20±1.36	58.33±1.10	58.00±1.86	60.00±1.09	59.00±1.44	N.S.
Albumen wt.%	62.82±1.83	63.96±1.78	63.71±1.66	62.69±1.00	63.33±1.87	N.S.
Yolk wt.%	24.53±1.56	24.62±1.75	23.64±1.71	24.37±1.86	23.70±1.79	N.S.
Shell%	12.64±1.89	11.42±1.64	12.65±1.65	12.94±1.47	12.97±1.43	N.S.
Shape index	77.18±1.56	78.03±2.50	76.45±1.03	76.73±1.81	76.76±1.61	N.S.
Yolk index	46.10±1.55	45.92±1.87	47.09±2.40	46.84±1.50	47.39±1.49	N.S.
Haugh unit	74.90±3.01	75.01±4.70	77.16±3.80	79.93±4.20	76.39±3.50	N.S.
Shell thickness, µm	323±17.60	325±15.2	337±12.30	330±14.10	338±19.10	N.S.

N.S. = non significant

The Effects of Garlic Levels on Yolk Cholesterol, Colk Total Lipids and Chemical Analysis of Egg

The effect of garlic levels on yolk cholesterol and yolk total lipids as well as the chemical analysis of egg are described in table (6). It must be mentioned that each of yolk cholesterol and yolk total lipids (mg/g yolk) significantly (P<0.01) decreased with the increasing of garlic in diet. Yolk cholesterol and yolk total lipids revealed values of 19.83, 18.64, 17.84, 16.27, & 15.90 and 331.7, 325.1, 304.8 & 300.2 for hens fed on diets supplemented with 0, 0.5, 1.0, 1.5 and 2% garlic, respectively. However, 2% garlic in diet followed by a decrease in each of yolk cholesterol and yolk total lipids with 19.8% and 9.5%, respectively, compared to those of the control group (Table 6).

TABLE (6). Effect of garlic levels yolk cholesterol, yolk total lipids and chemical analysis of egg (Means ± SE)

Traits	Garlic levels					Sig.
	Control	0.5%	1%	1.5%	2%	
Yolk cholesterol (mg/ g yolk)	19.83[a]±0.19 (100)	18.64[ab] ±0.18 (94.0)	17.84[bc]±0.21 ((90.0)	16.27[cd]±0.25 (82.0)	15.90[d]±0.19 (80.2)	**
Yolk total lipids (mg/g yolk)	331.7[a]±2.30 (100)	325.1[a] ±1.89 (98.0)	315.2[b] ±2.04 (95.0)	304.8[c]±2.10 (91.90)	300.2[c]±2.37 (90.50)	**
Chemical analysis of egg						
Moisture%	73.51±3.95	74.00±3.50	73.80±4.00	73.85±3.77	73.95±3.40	N.S.
CP%	12.10±1.2	12.70±1.33	12.55±1.50	12.80±1.63	12.63±1.70	N.S.
EE%	10.91±1.03	11.04±1.11	10.80±1.00	10.95±1.10	11.00±1.30	N.S.
Ash%	0.85±0.09	0.82±0.07	0.80±0.07	0.83±0.05	0.86±0.06	N.S.

Sig = Significance N.S. = not significant ** = (P< 0.01)
[a,b,c,d]Means with different superscripts in the same raw are significantly different (P< 0.05).

The results of the present study agreed with the findings of Sharma *et al.* (1979) who indicated that adding 1 or 3% garlic powder in Leghorn diets reduced egg cholesterol by 5.45 or 4.10% mg/g yolk, respectively. Also, Mohamed *et al.* (2000) recorded a reduction of 10 or 8% and 6.66 or 6.48 in yolk cholesterol and total lipids of IZA-Brown or Fayoumi layers, respectively. Furthermore, El-Kaiaty *et al.* (2002) noticed a reduction of 20% and 3% in yolk cholesterol and total lipids of laying hens fed on 2% fresh garlic in diet. In laying Japanese quail, El-Habbak *et al.* (1989) obtained a reduction of 59.5% in yolk cholesterol by feeding garlic up to 4% in Japanese quail diet.

Chemical composition (moisture, CP, EE and ash%) of egg as affected by garlic levels are presented in table (6). It was noticed that garlic levels had no significant effects on chemical composition of egg in all experimental treatments.

Blood Constituents as Affected by Garlic Levels

Serum Cholesterol

Serum cholesterol as affected by garlic levels are shown in table (7). It could be noticed a pronounced decrease in serum cholesterol with the increasing of garlic level in diet. This reduction estimated as 17.5% in 2% garlic group compared to the control group. However, serum cholesterol (mg/100ml) were 135.1, 148.6, 140.7, 131.0 and 126.3 for garlic groups 0, 0.5, 1.0, 1.5 and 2%, respectively. The differences among the experimental treatments were highly significant (P<0.01).

TABLE (7). Effect of garlic levels on blood constituents (Means ± SE)

Traits	Garlic levels					Sig.
	Control	0.5%	1%	1.5%	2%	
Serum cholesterol (mg/100 ml)	153.1^{a}±1.9 (100)	148.6^{a}±2.00 (97.1)	140.7^{b}±1.80 (91.9)	131.0^{c}±1.60 (85.6)	126.3^{c}±2.00 (82.5)	**
Serum total lipids (mg/100 ml)	1350^{a}±4.3 (100)	1342^{a}±5.90 (99.0)	1330^{b} ±4.7 (98.5)	1321^{b}±4.90 (97.9)	1313^{b}±5.60 (97.3)	**
Serum total protein (g/ 100 ml)	5.35±0.38	5.40±0.40	5.49±0.43	5.80±0.40	5.93±0.38	N.S.
Serum albumin (g/ 100 ml)	3.10±0.41	3.18±0.37	3.34±0.30	3.45±0.28	3.52±0.32	N.S.
Serum globulin (g/ 100 ml)	2.25±0.29	2.22±0.20	2.15±0.21	2.35±0.20	2.41±0.21	N.S.
Albumin/globulin ratio	1.38±0.20	1.43±0.18	1.55±0.15	1.47±0.15	1.46±0.18	N.S.
Ca (mg/100ml)	16.50±0.63	15.81±0.55	16.00±0.49	15.77±0.50	15.90±0.59	N.S.
Inorg. P (mg/100 ml)	4.91±0.23	5.09±0.18	5.10±0.20	4.93±0.25	5.30±0.19	N.S.
Ca/P%	3.36±0.23	3.11±0.20	3.14±0.20	3.20±0.27	3.00±0.21	N.S.
Serum glucose (mg/ 100 ml)	165.2^{a}±3.10 (100)	159.2^{a}±4.3 (96.4)	150.8^{b}±3.80 (91.3)	144.1^{bc}±5.20 (87.2)	140.2^{c}±3.73 (84.9)	**

Sig = Significance N.S. = non significant ** = (P< 0.01)

^{a,b,c}Means with different superscripts in the same raw are significantly different (P< 0.05).

The positive effect of garlic in reducing serum cholesterol in the present work was previously confirmed by Qureshi *et al.* (1983b), El-Deeb (1994) and El-Kaiaty *et al.* (2002). For example, Mohamed *et al.* (2000) reported a reduction in serum cholesterol by dietary garlic with 13.9% and 14.5% in ISA Brown and Fayoumi hens, respectively. In the same way, El-Kaiaty *et al.* (2002) reported that using dietary 2% garlic decreased serum cholesterol level by about 18% during 8 weeks of treatment. In other species, El-Habbak *et al.* (1989) reported a reduction in serum cholesterol with 50.3% in laying Japanese quail at a level of 4% fresh garlic. In broilers, Horton *et al.* (1991) reported a reduction of 10% in plasma cholesterol and plasma HDL cholesterol concentration at a level of 10 000 mg kg^{-1} dried garlic. Furthermore, Abdo (1998) estimated on broilers a reduction in cholesterol with 22.5% and 12.6% at levels of 3% and 6% fresh garlic in diet.

Serum Total Lipids

A significant (P<0.01) reduction of serum total lipids (Table 7) in the present work (particularly at the higher levels of garlic) were obtained. Values in this concern were 1350, 1342, 1330, 1321 and 1313 mg/100 ml for 0, 0.5, 1.0, 1.5 and 2% garlic groups, respectively. Hens fed on 2% garlic in their diet appeared a reduction of 2.7% in serum total lipids than those of the control group. However, the reduction in serum total lipids was less pronounced than cholesterol. Generally, Mohamed *et al.* (2000) reported that total lipids decreased at 8 week of treatment by about 3.4% and 5.1% in ISA Brown and Fayoumi hens, respectively. Also, El-Kaiaty *et al.* (2002) revealed a reduction of 4% serum total lipids in laying hens fed on 2% fresh garlic in their diets. Qureshi *et al* . (1983a) increased this value up to 26% in white Leghorns. In ducks, Ghazalah and Ibrahim (1996) reported a reduction of 37%, while Abdo (1998) reported a reduction of 18% and 16.9% in total lipids at 3 and 6% fresh garlic in broiler diets.

The discrepancy among the effects of garlic on the physiological parameters may be due to genetic differences between species, the duration of the experiment, the amount and type of garlic inserted in diet and/ or due to any other factors related to the experiment.

Serum Total Protein, Albumin and Globulin

The data showed that total protein, albumin and globulin (g/100ml) were insignificantly increased at the higher levels of garlic in diets (Table 7). However, Abou El-Wafa *et al*., (2002) came to the same conclusion. In contrast, El-Kaiaty *et al*. (2002) showed no positive effect of 2% garlic on serum total protein, albumin and globulin in laying hens. Also, Abdo (1998) found no significant effects of 3 or 6% fresh garlic on total protein of broiler chickens. The increase in total protein, albumin and globulin may be attributed to the increase in feed intake, which reflected in a higher body weight and finally a positive improvement in the metabolic process of the birds.

Serum Ca, Inorganic P and Glucose

. Ca and inorganic P (mg/100ml) showed no significant influence due to the different levels of garlic in diets. On the other hand, there was a significant ($P<0.01$) gradually decrease in serum glucose with the increasing of garlic level in diet (Table 7). Serum glucose values (mg/100 ml) were 165.2, 159.2, 150.8, 144.1 and 140.2 for hens fed a diet supplemented with 0, 0.5, 1.0, 1.5 and 2% garlic, respectively. In other words, garlic at a level of 2% reduced serum glucose with 15.1% compared to the control group. This result was in contrast with the finding of Horton *et al*. (1991) who found no significant effects of garlic levels on glucose in broilers. However, Ernst (1987) showed that garlic lowered blood glucose in broilers. Qureshi *et al*. (1983a) supported also the results of the present study, where they obtained a reduction of 33-39% in glucose-6-phosphate dehydrogenase by adding 3.8% from either garlic paste, solvent fractions or 0.14% garlic oil to White Leghorn diet. In the same manner, El-Habbak *et al*. (1989) reported that administration of garlic cloves or their extract significantly decreased blood sugar. Furthermore, El-Kaiaty *et al*. (2002) reported that 2% garlic followed by a reduction of 11% in serum glucose of laying hens.

A possible interpretation of the reduction in blood glucose when birds fed on garlic in their diets may be due to the presence of hexokinase in garlic cloves, whicht was found to phosphorylate D-glucose, D-mannose, D-fructose and D-glucoseamine with preferential action on glucose (Bhat and Patt-Abiraman, 1979). However, the inhibition was found to be dose-dependent and the degree of reduction increased with duration of treatment (El-Habbak *et al*., 1989).

Generally, the improvement in physiological traits (cholesterol and total lipids in serum and egg yolk) as a result of feeding garlic could explain that garlic has a very significant protective action against hyperlipaemia and hypercholesterolemia changes which are normal following fat ingestion (Qureshi *et al.*, 1983 a and b). The higher content of sulfer compounds in garlic is also responsible for inhibiting biosynthesis of cholesterol and lipids (Sklan *et al.*, 1992). Also, Sendle *et al.* (1992) demonstrated that garlic could reduce serum cholesterol level, primarly by inhibiting cholesterol synthesis, if taken in sufficient amount, while Yeh and Yeh (1994) suggested that hypocholesterolaemic effect of garlic stems, caused in part, from decreased hepatic cholesterogenesis, whereas the triacylglycerol-lowering effect appears to be due to inhibition of fatty acid synthesis. Garlic is considered as antiatherosclerotic agent due to its essential oil which prevent fat-induced hyperlipemia mainly through the inhibition of the key enzyme in cholesterol and lipid synthesis (Konjufca *et al.*, 1997). However, members of the lily family (garlic and onion) are high in vit. C and contain quercetin and adenosine which are thought to fight LDL, an undesirable type of cholesterol (cited by Abou El-Wafa *et al.*, 2002).

Economical Evaluation

Economical evaluation as affected by garlic levels are reported in table (8). The positive effect of garlic (at a level of 1.5%) on egg production percentage and egg mass were clearly reflected on the economic efficiency. The best economic efficiency was noticed in 1.5% garlic group followed by those fed on 1% garlic. These results agreed with the findings of Shi-Xiaohua *et al.* (1999) who reported that the highest profit was obtained when broilers fed on a diet supplemented with 1% garlic. However, Abdo (1998) reported better economical efficiency but at a higher level of 3% garlic and not at 6% in broiler diets, while Abou El-Wafa *et al.* (2002) recorded the best economic efficiency when rabbits fed on a diet supplemented with 1% dried garlic powder.

TABLE (8). Economical evaluation as affected by different levels of garlic

Items	Garlic levels				
	Control	0.5%	1%	1.5%	2%
Total feed cost LE/hen	11.45	11.41	11.59	11.93	11.75
Egg mass, Kg/hen	4.443	4.658	4.775	5.088	4.760
Price/Kg. Egg, LE	4.50	4.5	4.5	4.5	4.5
Total revenue	19.99	20.96	21.49	22.90	21.42
Net revenue	8.54	9.55	9.90	10.97	9.67
Economical efficiency	0.746	0.837	0.854	0.919	0.823
Relative economical efficiency	100	112	114	123	110

Although garlic supplementation in birds diet showed positive effects under normal conditions, it may has some advantages related to heat tolerance under high environmental conditions. Tollba and Hassan (2003) confirmed this assumption when they reported that body temperature and respiration rate were significantly ($P<0.05$) decreased after heat exposure for broiler chicks fed garlic comparing to control birds. This improvement may be also due to some biological function of components or pharmacological activities of garlic. The improvement of garlic supplementation under high temperature conditions may be attributed to its effect on thyroid gland hormones which increase metabolic rate (Tollba and Hassan, 2003). However, literature on the effects of the natural feed additives under high environmental conditions are very rarely and need more studies.

In conclusion, fresh garlic could be recommended at a level of 1.5 kg/100 kg diet of laying hens during summer period under the desert conditions. This could improve the egg production, feed efficiency utilization, reduces the cholesterol and total lipids in blood and egg yolk and may reduce the side effects of high temperature or any stress conditions.

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استخدام الثوم كإضافة طبيعية في علائق الدجاج البياض تحت الظروف الصحراوية

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نفذت هذه التجربة البحثية في محطة بحوث رأس سدر بجنوب سيناء خلال أشهر الصيف (في الفترة من ١ مايو وحتى ٢١ أغسطس) وذلك لتقييم الثوم كأحد الإضافات الطبيعية في علائق الدجاج البياض وعلاقته بالتغير في وزن الجسم، إنتاج البيض، معدل الاستفادة من الغذاء، معاملات الهضم، نوعية البيضة وبعض المقاييس الفسيولوجية لصفار البيض والدم.

استخدم في هذا البحث عدد ٦٠ دجاجة بياضة عمر ٢٠ أسبوع من سلالة هاى لاين بنى حيث وزعت عشوائيا في ٥ مجموعات تجريبية بواقع ١٢ دجاجة لكل معاملة، تقع في ٣ مكررات حيث اشتملت كل مكررة على ٤ دجاجات. أضيف الثوم الطازج إلى العليقة بمستويات صفر، ٠٫٠٥، ١، ١٫٥ و ٢ كجم/١٠٠ كجم عليقة.

أوضحت الدراسة بان الثوم بمستوياته المختلفة لم يكن له تأثيرا معنويا على وزن الجسم النهائي وكذلك التغير في وزن الجسم على الرغم من أن إضافة الثوم بمعدل ١٫٥ كجم/١٠٠كجم عليقة أوضح أعلى القيم (١٨٠٣ ، ٢٦٨ جم) لهاتين الصفتين السابقتين مقارنة بالمجاميع التجريبية الأخرى.

زاد معدل إنتاج البيض بصورة معنوية وذلك بزيادة معدل إضافة الثوم إلى العليقة وكان ذلك جليا عند مستوى ١٫٥ كجم سواء خلال الفترات البينية للتجربة أو في المتوسط العام للفترة التجريبية. لم يكن هنالك تأثيرا معنويا لمستويات الثوم المختلفة على وزن البيضة بينما سجلت كتلة البيض قيما أعلى (٥٫٠٠٠٨ كجم بيض/دجاجة) عند المستوى ١٫٥ من الثوم بينما كانت أقل قيمة في مجموعة الكنترول (٤٫٤٤٣ كجم بيض/دجاجة).

زاد معدل استهلاك العليقة تدريجيا بزيادة مستوى إضافة الثوم في العليقة، بينما لم يكن هناك تأثيرا معنويا لمستويات الثوم المختلفة على كفاءة التحويل الغذائي كمتوسط عام خلال الفترة التجريبية. لم تتأثر مقاييس البيض النوعية بمستويات الثوم المختلفة. حقق المستوى ١٫٥ كجم من الثوم أفضل كفاءة اقتصادية متبوعا بتلك المجموعة التي غذيت على عليقة أضيف إليها الثوم بمعدل ١ كجم/١٠٠ كجم عليقة. كانت هناك زيادة معنوية في معامل هضم الدهون بزيادة معدل إضافة الثوم إلى العليقة.

لم يتأثر التركيب الكيماوي للبيضة (نسبة الرطوبة، البروتين، الدهون والرماد) بمستويات الثوم المختلفة. انخفض مستوى كل من الكوليسترول والليبيدات الكلية بصورة معنوية في صفار البيض وأيضا كل من الكوليسترول، الليبيدات الكلية والجلوكوز في سيرم الدم تدريجيا مع زيادة معدل إضافة الثوم إلى العليقة. زادت بصورة غير معنوية قيم كل من البروتين الكلى، الألبيومين والجلوبيولين في السيرم بزيادة معدل إضافة الثوم إلى العليقة بينما لم تتأثر قيم كل من الكالسيوم والفوسفور بتلك المستويات.

خلصت الدراسة إلى انه يمكن استخدام الثوم الطازج بمعدل ١٫٥ كجم /١٠٠ كجم عليقة حيث أدى ذلك الى تحسن واضح في معدل انتاج البيض ومعدل الاستفادة من الغذاء وقلل في الوقت ذاته من محتوى الدم وصفار البيض من كل من الكوليسترول والليبيدات الكلية علاوة على ماقد يكون له من آثار ايجابية تحت الظروف الصحراوية خلال أشهر الصيف.